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APPENDIX II

EVALUATION REPORT

EAST AFRICAN FOOD CROPS RESEARCH PROJECT

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EVALUATION REPORT

EAST AFRICAN FOOD CROPS RESEARCH PROJECT

Introduction

The Project Evaluation Team was requested by USAID/Kenya to evaluate past and present sub-projects that had been carried out by the Mission since October 1, 1977. These sub-projects were originally developed by a team in early 1975 and described in a report dated April, 1975, entitled "East African Food Crops Research Project" and numbered 618-110-10-657, referred to by USAID as "the green book". The East African Community was dissolved in July, 1977. Subsequently, the East African Agriculture and Forestry Research Organization (EAAFRO) was disbanded. To ensure continuation, the Government of Kenya had to assume support of the sub-projects under the Food Crops Research Program that was physically located in Kenya. USAID/Kenya accepted these activities as part of the country program effective FY 78. This Team was asked specifically to evaluate various sub-projects which included: the Protein Quality Laboratory at Kitale; the Maize Breeding Methodology Research; the Disease Element of Maize Research; the Plant Quarantine Station; and the Cropping Systems for Marginal Rainfall Areas. These were to be evaluated for their impact to date, importance of research and relationship to the Kenya context, relationship to GOK priorities and desirability as to continuation.

As these sub-projects were developed to serve the East African Community rather than any individual country, their relevance to serve agriculture development in Kenya rather than EAC as a whole has been considered. The goals, purposes and outputs, as well as the scheduled inputs, that were contained in the PP revision are not completely relevant under the present situation. An attempt has been made to review and evaluate the sub-projects based upon the existing situation in Kenya but with due consideration to regional concepts that prevailed when the various projects were originally designed. The concept of strengthening EAAFRO has now changed to institutional building at KARI. The training components originally programmed in the PP revision have not been critically reviewed due to the changing situation. It is noted, however, that this aspect of the activities scheduled under the PP have been delayed and at present no substantial plans exist that would allow the sub-projects to meet the established goals.

The Team used the origianl project description to determine the objectives and work plan as well as recently prepared work plans furnished to USAID by the technicians. Accomplishments were measured against available information that indicated the situation when the activity was started. The additional work required and recommendations are based upon the consensus of the Team after reviewing each sub-project.

In the opinion of the Team, activities carried out on a regional basis, as under EAAFRO, often may justifiably be devoted primarily to basic research, whereas country specific research projects should have greater practical application. The original report referred to above made no significant reference to recipients or a target group. The basic thrust was to conduct research in specific areas and to develop research methodology as well as specific research capabilities within the cooperating organization.

The Team spent approximately one week in Nairobi reviewing project documentation, discussing the projects with USAID, studying assessments of related projects, interviewing the USDA PASA team members and meeting with the Director of Research in the Ministry of Agriculture, Mr. D. M. Thairu, and Dr. F. Wang'ati, Acting Director of the Kenya Agriculture Research Institute. The second week was spent in visiting research stations at Kitale, Katumani and Kampi ya Mawe. In addition, the station at Muguga was visited on two occasions and detailed discussions were held with various MOA scientists and technicians.

The Evaluation Team wishes to thank all of those people since without their candor in our discussions, this evaluation would have been extremely difficult and less complete. The dedication of these people to their work and enthusiasm for their projects is outstanding, especially in view of the uncertain circumstances brought about by the collapse of the East African Community.

SUB-PROJECT A: MAIZE IMPROVEMENT

A-1 - Regional Protein Quality Laboratory

Background

Maize is an important human as well as livestock food in Kenya. In the highlands it is grown primarily as a commercial crop, whereas in the lowlands it is usually grown as a subsistence crop. Much of the commercial maize is sold to the urban population where the low income people depend on it as their primary food. These urban people, as well as the subsistence farmer, could benefit nutritionally from improved maize quality.

Adequate protein in the diets of people, who have little variation in their diet and depend heavily on the cereals, has been a concern in many developing countries. The discovery of genetic mutants with improved protein quality (higher levels of the essential amino acids, e.g., lysine and tryptophane) opened up the possibility of improving protein quality through breeding.

Protein quality and/or quantity is not a visible trait that can be detected in a segregating or variable population. Laboratory tests are necessary to identify total protein and specific amino acids. Conversion of breeding populations to the Opaque-2 (high protein quality) version is underway in Kenya at the Kitale, Embu and Katumani research stations. These programs are dependent upon a laboratory for evaluation of their many lines if the breeding and selection effort is to succeeed.

A proposal for the establishment of the laboratory was presented by EAAFRO, and eventually funded by USAID in late 1975 as a sub-project of the Food Crops Research Project. USAID was to fund the cost of the laboratory equipment and initial stock of chemicals and supplies, as well as office equipment and participant training. In addition, a USDA technician was to be provided under a PASA for four years to direct the establishment and early operation. The USDA technician arrived in October, 1976, but left in January, 1978, after only approximately 14 months on assignment. He has not been replaced.

Objectives

The objectives were:

(1) To establish in EAAFRO a Protein Quality Laboratory for support of breeding programs to improve protein quality of maize (initial analysis was to be on maize but as breeding methods were more clearly defined elsewhere, at least the millets and sorghum were to be included). (2) To coordinate and assist national and

and EAAFRO breeders in the interpretation and utilization of the laboratory data.

Plan of Work

USAID assistance was programed for four years during which time a U.S. technician was to be posted to assist in the establishment, training of personnel and operation of the laboratory. Concurrently with posting of the technician, EAAFRO would start development of the physical facility to be located at Kitale. A new maize laboratory was to be constructed that would provide space for the protein laboratory, office and storage space, and houses for the technicians. Also, EAAFRO was to identify and post two East African counterparts who would serve as laboratory technicians, one senior laboratory assistant, two laboratory assistants, one clerical officer and a part-time secretary.

Initially, the two counterparts to the USDA technician were to receive 12 months of technical training in the U.S. After returning to Kitale, the responsibility for the laboratory was to be transferred gradually to them. At the end of four years they were to assume full responsibility and the USAID commitment was to be completed.

The senior laboratory assistant was to be identified early in the life of the project and sent to CIMMYT for six weeks of training. After he returned, a second laboratory assistant was to be sent to CIMMYT for similar training.

Accomplishments

A. Physical

The physical facilities planned for the maize project, which included the quality laboratory, storage space, etc., were completed in early 1976. Equipment was installed, initial supplies purchased, and the laboratory opened in late 1976. After operations necessary to calibrate equipment and check procedures, the laboratory was ready for the analysis of samples.

B. Technical

The first technical laboratory work started in late 1976 with the standardization of analytical procedures. All techniques were checked on previously tested samples from CIMMYT to indicate accuracy and consistency with other laboratories. At one point, considerable difficulty was encountered in the standardization process.

Eventually, this was determined to be due to enzymes that had become partially inactivated by high temperatures encountered during shipment. After receiving new chemicals from Europe, the laboratory variability has been within acceptable levels. Since February, 1977, approximately 2,200 samples have been analyzed for total protein and tryptophane with 20% of the total number analyzed for lysine. Lysine analysis is more difficult and, since the quantity of lysine and tryptophane are normally highly correlated, only 20% of the samples were checked for both. The Micro Kjeldahl method is used for total protein and the colorimetric method for lysine. For lysine samples, analysis with a UV spectrophotometer is necessary. The procedures used are those developed at Purdue University. Analysis is made only on the endosperm, which is also analyzed for oil content. In addition, 50 sorghum samples were analyzed for protein quality and some sunflower samples were analyzed for oil content.

C. Impact on Kenya

Operation of this laboratory makes it possible for Kenyan maize breeders to select for protein quality and quantity. Thus, it is now reasonable to expect that the maize eaten in Kenya will eventually add measurably to the nutritional balance needed for good health. The maize breeders selecting for protein quality and quantity at both Katumani and Kitale indicated that the samples from their selection programs had been analyzed promptly.

Additional Work Required

The laboratory is adequately equipped to carry out the present workload, although there is concern for the future. Expendable items, such as chemical and glassware, are in short supply. The UV spectrophotometer, which was borrowed, had to be returned to a Nairobi laboratory and the Kenyan technicians have had to go back to the colorimetric method of analysis for lysine. This is slower and there is a greater chance for error due to the interference of natural corn pigments. One of the three Micro Kjeldahl units is awaiting repair and this has slowed operations. The staff desires to shift to a dye binding technique of protein analysis as a means of increasing capacity if a DBC unit can be acquired. To be fully operational and to expand the workload, several pieces of equipment, that are used in many routine laboratory procedures, and various supplies and chemicals are needed.

There is shortage of supervisory staff in the laboratory. A third biochemist hopefully will soon be appointed. Only one of the biochemists operating the laboratory has received training beyond the B.Sc degree and that was a three months training program at CIMMYT. Additional training is needed by this staff if it is to be capable of solving analytical and instrumentation problems which

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The laboratory presently is lacking several small pieces of equipment that are essential to the efficient operation of a biochemical laboratory. In addition, two major instruments (U.V. Spectrophotometer and DBC units) are recommended for purchase with USAID funds. It is also recommended that funds be made available for purchasing a sufficient amount of chemicals and supplies to insure continued operation of the facility.

A-2 Disease Resistance in Maize

Background

At the time this project was initiated, there had been no significant effort to breed disease resistant varieities of maize in Kenya. Several diseases had been identified and, at least one, Maize Streak Virus Disease, was reported to be serious. The occurrence and severty of specific disease are understood to vary greatly between the high (high rainfall) and low (dryland) elevations.

Maize Streak Virus (MSV) was thought to be the most serious disease at the lower and middle elevations (below 5,000 feet). Other diseases of maize previously reported in the lower elevations include Southern Maize Rust (Puccinia polysora), Southern Maize Leaf Blight (Helminthosporium maydis), and two virus diseases, Maize Stripe and Maize Line, that have been of minor importance. At the higher elevations, Sugarcane Mosaic Virus (SMCU) was considered the most important virus disease. Puccinia sorghi was considered to cause the major rust disease, and Helminthosporium turcicum the most common leaf blight.

Maize Streak Virus Disease has been investigated more extensivel than the other diseases because of its reported seriousness. It was first described in Tanzania in 1925 and shown to be transmitted by leafhoppers. Although the severity of the disease varies from year to year, it has been estimated that losses of 50 percent occur when the disease is severe. The disease has been prevalent for many years but resistance does not appear to have evolved in indigenous maize. However, Bock and Guthrie, virologists with the British Overseas Development Ministry (ODM) at Muguga, have found several sources of resistance in plant introductions. Seed for these sources is available for use by breeders. Regrettably, no concerted effort has been made to incorporate this resistance into an acceptable variety.

The breakup of the East African Community disrupted plans to conduct the program for breeding maize resistance to MSV in Tanzania. This location had been selected because a high incidence of the disease occurs regularly under conditions occurring naturally at this location.

Objectives

The original objectives of the disease resistance work in maize were:

1. To establish EAAFRO research in the lowland maize area where Streak and other diseases are severe.

2. To incorporate resistance to MSV into adapted low altitude composites.

3. To determine the inheritance of resistance to MSV as a prerequisite to determining the most suitatable type of breeding program.

4. To search for andincorporate resistance in maize lines to Sugarcane Mosaic Virus Disease, Southern Leaf Blight, Southern Maize Rust and other diseases of economic importance.

5. To begin simultaneous incorporation of Opaque-2 and the subsequent selection for vitreous endosperm in the diesease resistant populations.

Plan of Work

Initial emphasis of this sub-project was to screen germplasm for resistance to MSV and initiate a breeding program. The specific plan of work to accomplish this and the other original objectives was to be developed by the technician. Dr. Raymond Louie was recruited as the USAID project technician. Upon his arrival, he was told that the two virologists at Muguga, who are with the ODM, were adequately covering the work on MSV. These virologists and Dr. Harry Kulkarni, who had worked on SCMV, indicated that SCMV might be causing a more important disease problem than MSV, especially in the Kitale area. Accordingly, Dr. Louie developed a plan of work in which he was to survey for Streak during the two growing seasons in 1977 at 13 sites along the coast from Mtwapa to Tanzania to determine the importance of this disease.

The results of the Streak survey, and the realization that the two British virologists were already working on Streak, led Dr. Louie to develop a plan of work primarily concerned with SCMV. His plan called for the following activities on maize and sugarcane:

1. Screen for SCMV resistance in indigenous (77 entries) and imported (30 entries) maize hybrids, inbreeds and lines.

2. Screen for SCMV resistance in sugarcane in the plant quarantine collection.

3. Select and increase resistant progenies from the screening program of maize and sugarcane.

4. Determine the incidence, prevalence, and importance of SCMV in Kenya and Tanzania in maize and sugarcane.

5. Assess disease loss in maize caused by SCMV.

6. Determine the important sources of inoculum responsible for initiation of epidemics caused by SCMV.

7. Monitor SCMV disease in maize at Muguga and Kitale.

8. Evaluate the reaction of maize entries in varietal and nursery trials at Kitale to SCMV and MSV.

9. Collect, isolate and characterize isolates of SCMV.

10. Identify, characterize and determine the prevalence and importance of new virus diseases of maize and sugarcane.

Accomplishments

A. Technical

The survey for Streak in the coastal area demonstrated that this virus was not as common as previously thought, althought it must be recognized that this was a small survey limited to two growing seasons. Incidence of disease was always less than 10 percent and usually less than 0.1 percent.

In the survey for SCMV, disease occurred from Machakos to Kitale, but it was not found in the lowland areas. The occurrence varied with the time of year. The incidence was 100 percent in several nursery plantings. In small fields it ranged from 0-100 percent. In well fertilized and cultivated plots in which commonly used hybrids were artificially inoculated, yield was reduced from 20 to 45 percent, depending upon the stage of plant development at the time of inoculation. The relevance of this data to yield loss in maize grown with cultural practices used by Kenyan farmers is unknown, but it is evident that the disease is potentially very serious.

During the survey for SCMV, it was observed that rust disease and aphids are very common at Kitale. Leaf blight was also observed but the incidence and importance was not determined. It was further observed that lodging is a very serious problem that leads to rotting of ears.

During this study by Dr. Louie, 80 sources of maize germplasm were evaluated for resistance to SCMV. Individual plants from three of these sources remained healthy after being inoculated two times. Seed from these will be planted and further evaluated for resistance.

Dr. Louie found five grass species that are natural reservoirs of SCMV. An additional grass species, that is also a reservoir of SCMV, was discovered by Dr. Bock. The significance of these hosts as sources of inoculum for initiation of epidemics is unknown.

Observations of SCMV disease under field conditions led to the conclusion that breeders would be most likely to encounter a high incidence of naturally occurring disease in late season plantings at Kitale. Muguga would probably be a reasonably good location for screening, although less so than Kitale.

An extensive evaluation for resistance of maize to SCMV was made on germplasm of interest to the Kenyan Seed Company, Maize Genetics Laboratory, and the Government of Kenya. As part of this work, Dr. Louie trained Winston Mgonjwa, a laboratory assistant at Kitale, to evaluate and record the reaction of germplasm to SCMV. Because of this training, he also has been able to carry out a study using trap plants to monitor the incidence of SCMV in the maize nursery at Kitale.

To determine if there are strains of SCMV, which is essential to a breeding program, samples of the virus were collected from 80 sites and from trap plants. Six of these isolates that were obtained from different geographical areas are being characterized now by serology, virulence on differential hosts, and vector specificity.

In summary, these studies have shown for the first time the importance of SCMV on maize in Kenya. Furthermore, promising sources of resistant germplasm have been identified and methods have been developed to work with the disease in breeding plots.

In work on sugarcane, germplasm from many sources has been inoculated with SCMV and found to be resistant. However, because there is no sugarcane breeder in Kenya, these have not yet been used in a breeding program. In another experiement, tentative evidence has been obtained to indicate that strains of SCMV exist. This was based upon an experiement in which the virus was isolated from three locally grown sugarcane varieties that are considered to be quite resistant, moderately resistant and susceptible. When each of these three virus isolates was inoculated into each of the three sugarcane varieities, it was found that not all isolates would infect all varieities. The significance of these strains in a sugarcane or maize breeding program has yet to be determined.

Besides accomplishment in these research areas, Dr. Louie has trained two individuals employed at Muguga. Both have had college training but, unfortunately, neither has a B.Sc. degree so their career opportunities may be limited. However, they are ambitious, dedicated workers who would profit from further training. Jackson Njuguna has worked at Muguga for five years and has been trained to purify viruses, prepare antisera and conduct serological tests, identify viruses using indicator plants, survey for diseases, run statistical analysis, and do other field work such as planting, inoculating plants with viruses, and pollinating plants. Robert Opundo has worked at the laboratory for four years. He has developed special competency as a vector specialist, i.e., rearing insects and using them to transmit viruses. He is presently learning the laboratory, greenhouse and field aspects of virology.

B. Significance for Kenya

The practical significance of this work is limited until the information and procedures developed during this study are used in a breeding program. However, because this study demonstrated the importance of SCMV in maize, it is likely that breeders will begin to develop varieties resistant to this virus. If this effort is made, the studies of Dr. Louie and the skills of the laboratory assistants, who have been trained to work with SCMV, will greatly expedite the breeding program. In view of the yield loss SCMV has been shown to cause in maize, the development of resistant varieties could help to insure adquate food supplies for Kenya.

Additional Work Required

Work should continue on selecting maize with resistance to viral and other diseases. Emphasis should be on identifying resistant germplasm that is adapted to the environmental conditions occuring in Kenya. In related work, the genetics of resistance should be determined for the most promising sources of resistance. Finally, these sources of resistance should be used in a breeding program to produce agronomically acceptable, disease resistant maize. The final step should be to furnish the finished material to commercial seed multipliers.

It is considered essential to continue the disease survey work to identify the diseases of maize in Kenya and to determine their incidence and severity in different geographical areas during several planting seasons. This should be done in farmers' fields and routinely in all research plots involving breeding, regardless of the objectives of the breeding program. This will avoid releasing new varieties with increased susceptibility. Similar work should be done for all crops having potential in the marginal rainfall areas, i.e., survey in farmers' fields and all research plots concerned with breeding and developing cropping systems for the marginal rainfall areas.

Summary and Recommendations

Streak Mosaic Virus was found not to be severe in the coastal area during the two growing seasons in which the surveys were made. Sugarcane Mosaic Virus, however, was found to be much more common and severe than previously known in the areas from Machakos to Kitale. Sources of resistance to SCMV were identified and later season plantings at Kitale were found to give a high incidence of naturally occurring disease, making this area useful for evaluating germplasm for resistance, An extensive collection of isolates of SCMV has been made from maize and work is in progress to characterize them to determine if strains of the virus exist. Preliminary evidence with isolates from sugarcane suggests that this is quite likely but this needs to be verified and the importance of these strains in breeding programs determined.

A special effort should be made to familiarize the Kenyan maize breeders with the SCMV and MSV problems, their distribution, significance, and sources of resistant germplasm. Dr. Louie should offer to work with each of the maize breeders to help them initiate a program to breed for resistance to these two viruses.

In terms of training, an assistant at Kitale was trained to score breeding material for incidence of SCMV and two employees at Muguga---neither of whom has a B.Sc. degree--were trained to do many of the techniques used in laboratory, greenhouse and field studies of viruses and virus diseases.

It is recommended that an experienced, general plant pathologist (or an extension specialist with experience in applied research), preferably with some familiarity with virus diseases and disease resistance work, be assigned to replace Dr. Louie at the end of his tour of duty to continue the additional work described in Section 5. Provision should be made to employe a specialist on a TDY basis to assist this generalist, should the need develop. This position is envisioned as involving disease diagnosis and survey work, and providing backup for breeding programs on maize and other crops being developed for marginal rainfall areas.

It is also expected that the technician will make a firm commitment to training. Efforts should be made to provide training leading to an academic degree to the two assistants now involved with the program.

The technician doing this work should be given an annual budget for routine maintenance and operating costs and to hire local help. The lack of these funds has severely hampered the present technician. Presently, the laboratory supplies and equipment are totally inadequate for even the simplest tasks. This prevents accomplishement of the research mission and is counterproductive to the training effort.

At this time research on virus diseases can be accomplished only because the British virologists stationed at Muguga permit the technician to use their equipment and supplies. This is only a temporary solution since they may leave and remove their equipment or the equipment will wear out from excessive use. In addition to purchasing items to maintain and operate the laboratory, there is an equally strong need for greenhouse supplies and equipment for field plot work.

A vehicle is also essential to the success of this program since the majority of the work is done in the field.

A-3 - Continuation and Transition of Maize Breeding Methodology Research

Background

Maize (*Zea mays* L.) is an important food crop in Kenya. There were 483,000 hectares of maize planted in pure stands and 1,212,000 hectares in mixed stands reported for 1975. In 1976, production was estimated at 2,469,000 metric tons. Improved maize varieties are important to small as well as large scale farmers. Of the estimated 585,724 hectares planted to hybrid maize in 1977, 512,829 hectares were on small scale farms and only 72,896 on large scale farms. Programs in maize breeding have a major impact on the productivity of the small farmer.

The breeding methods research on maize was initiated at Kitale in 1964 by USDA/PASA technicians, in cooperation with EAAFRO, to compare several different methods of recurrent selections in local and introduced populations of maize. The project was designed to assist national programs in East Africa in the selection of breeding methods suited for their individual situtations. The breeding methodology study was administered, starting in 1964, under the EAAFRO Major Cereals Project. In 1972 the Major Cereals Project was terminated and the methodology research became a part of the Food Grains Research Project. The study was continued for an additional two years beginning in 1975 under the Food Crops Research Project but this arrangement was terminated in 1977 with the breakup of the East African Community. At this time the GOK assumed responsibility for what remained of this former EAAFRO activity. A USAID maize geneticist directed the project until the last technician, Dr. L.L. Darrha, left in 1977. At about this same time Dr. S. Mukuru, his EAAFRO counterpart from Uganda, also left, to accept a position with ICRISAT, leaving no continuity of leadership for the project. As a part of the national program, the senior maize breeder is located at Katumani where he also serves as Officer in Charge of the station. The work at Kitale is now under the direction of a young maize breeder who is completing his MSc degree at the University of Nairobi.

Objectives

The objectives of this project were:

1. To compare various techniques and methods within a comprehensive breeding system outlined by Eberhart, Harrison and Ogada.

2. To demonstrate the effectiveness of the system.

In later years the following additional responsibilities for the maize geneticist were added to the project:

1. To supply improved germplasm to breeders in Kenya and other parts of East Africa.

2. To coordinate high altitute regional varieity trials as well as to cooperate in the low altitude trials.

3. To provide for training in the program at Kitale for maize breeders.

In 1975 some transition of emphasis was made and additional responsibilities were added:

1. To begin conversion of some improved populations to Opaque-2 with hard endosperm in both high and low altitude maize.

2. To assist in the establishment of the Protein Quality Laboratory at Kitale.

3. To guide and consult with the pathologist when the resistance program for low altitudes was intiated at Kihaba.

Plan of Work

The comprehensive breeding system provided the possibility of either releasing a variety after each cycle of improvement or when facilities for producing hybrids had been developed. Two divergent but adapted populations with considerable gentic variation were used. These were KII (developed at Kitale) and Ec 573 (introduced from Ecuador). A heretotic response would be expected from the population cross hybrid (KII x Ec 573).

Methods of intrapopulation improvement utilized were mass selection (at 2% and 10% selection intensity), ear-to-row selection (with or without selection of the male plants at two plant populations), S_1 testing, half-sib selection (using high yield, low yield and inbred line testers) and full-sib family selection. All methods were utilized

in a random mated population of KII x Ec 573 (KCA). Methods of inter-population improvement within the separate KII and Ec 573 populations were ear-to-row, S_1 testing, and reciprocal recurrent selection.

Selection was to continue through 10 cycles with 3 years of evaluation of the selection methods. The size of the study precluded a single evaluation trial. Therefore, related experiments were grouped to give four separate trials. Three of these were to estimate gain from selection by the different methods while the fourth was designed to show the effect of plant population on gain from selection. A regional variety trial for the high altitudes was to be organized and developed in which potentially promising lines were evaluated. Young maize breeders from East Africa were to be sent to Kitale to gain experience in breeding methodology. Improved populations were to be released to maize breeders in East Africa.

After the 1975 review, the project was shifted to give more emphasis on protein quality and disease resistance. The Opaque-2 gene, which is associated with improved protein, was to be utilized in the conversition of improved populations adapted to both high and low altitudes. Selection for protein quality was dependent upon establishment of the Protein Quality Laboratory where analyses would be made to identify desirable segragates.

The maize geneticist was to guide and consult with the pathologist involved with the maize streak disease resistance program, which was to be located at Kibaha. The nature of direct involvement would be developed in consultation with the plant pathologist. Once resistance was identified it would be incorporated into the program.

Accomplishments

A. Technical

All cycles of the original selection methods study have been completed, although three methods for study were added later and have not been completed. To be completed, with the earliest evaluation date, are: (a) S_1 selection in Kitale II and Ec 573 (S21, cycle 5, 1981 and S22, cycle 5, 1980), (b) reciprocal recurrent selection with an inbred tester in KII and Ec 573 (RI23, cycle 10, 1985 and RI24, cycle 10, 1985), and (c) mass selection in KCA at a low population density (M17, cycle 10, 1979 and M10, cycle 15, 1979).

Six years of selection of the original experiements, followed by two years of evaluation, show ear-to-row selection to be the more effective intrapopulation improvement method. If a hybrid or variety cross is potentially usable, reciprocal recurrent selection appears to

be the best interpopulation approach. Initially, the variety cross Syn 2 could be released with no additional breeding effort. Variety crosses or traditional hybrids from extracted lines could be used as farmer husbandry and seed production facilities develop. As the program progressed through the years, breeders in national programs were informed of progress and results through regional workshops conducted on a biannual basis. At least eight technical papers have been published in technical journals reporting some aspect of the research. Other data await analysis because both the USAID and EAAFRO technicians left the project in 1977.

Until the breakup of the Community, the regional variety trials were coordinated from Kitale by the staff of this project. The results were analyzed by country and altitude zones and the report distributed in mimeographed form. Seed of entries from Kenya, EAAFRO, Kenya Seed Company, Uganda, Tanzania, Zaire and Zambia was packed, randomized, and distributed to over 100 cooperators for the 1976-77 trials. A variety trial is still grown within Kenya as part of the national program but the regional trial, as formerly handled, has been discontinued.

Six young Africans served as research assistants with the project at Kitale and received some training. These people now serve as breeders in different East African countries. Annual planning conferences were conducted for Kenyan breeders and classes in breeding methods were conducted both at Kitale and at the University of Nairobi.

Breeding for improved protein quality was started in the Kenyan national program and expanded in the EAAFRO project. The Opaque-2 gene was introduced into improved maize populations adapted to both high and low altitudes. Work in this area is now conducted in the national program and the effectiveness is enhanced through the services of the Protein Quality Laboratory.

In cooperation with the maize pathologist, germplasm was screened for resistance to sugar cane mosaic virus and resistance identified.

The Protein Quality Laboratory was established at Kitale. This is discussed as a separate sub-project but national breeders attest to the fact that the services have been invaluable and absolutely essential to their programs. The USAID maize geneticist was instrumental in initiating and planning for the facility as well as being involved in its organization to service the breeding programs.

B. Impact on Kenya

The maize breeding methodology study was designed to develop and evaluate suitable breeding methods for use in less developed countries. In the course of the study, populations and lines were developed that had potential both for immediate use as varieties as well as genetic material for continued input into a population improvement program.

The program has had an impact in three areas in Kenya. First, as a result of the methodology study, the maize breeding effort in the national program at all four locations was shifted to some form of population improvement by 1973. This has been continued.

Second, the populations utilized and improved in the methodology study were made available for commercial use and have been utilized commercially in Tanzania, Ethiopia, Uganda, Zambia and other African countries as well as in Kenya. According to figures supplied by Kenya Seed Company, the sole provider in Kenya of seed of improved maize varieties, the material from the methodology program is involved in slightly over 90% of the seed sold in Kenya. The total impact can be measured not only in terms of the varieties currently sold but also in terms of the increased acceptance of improved maize varieties. In 1976/77 the quantity of seed sold of improved varieties was 6.4 times that sold in 1976/68. According to Kenya Seed Company, 90% of the maize seed sold (122,240,000 kg.) in 1976/77 went to farmers cultivating from ½ to 50 acres with 70% of the total going to those cultivating less than 5 acres. The increased production over old varieties is (based on yield data) estimated by the Kenya Seed Company staff to have had a value of 45.8 million dollars during 1976/77.

Third, there was some contribution from the program in the training area. The senior maize breeder in Kenya worked with the USDA technician as did five other breeders in the former Community. This technician also conducted annual planning conferences as well as organized classes for workers on other crops at the Kitale Station and at the University of Nairobi. He advised the Kenya Seed Company on seed production techniques.

Additional Work Required

The selection phase of the original 17 experiments has been completed as well as one of the experiments initiated later. Two experiments are yet to be completed. They are:

(1) S_1 selection in Kitale II and Ec 573 (S21, cycle 5, 1981 and S22, cycle 5, 1980).

(2) reciprocal recurrent selection with an inbred tester in Kitale II and Ec 573 (RI23, cycle 10, 1985 and RI24, cycle 10, 1985).

(3) mass selection in KCA at a low population density (M17, cycle 10, 1979 and M10, cycle 15, 1979).

The evaluation trials for the original experiments have been completed but still remaining is the evaluation of the three experiments listed in the previous paragraph. After the date listed above for the completion of selection, three years of evaluation should be completed. The publication of experimental results beyond the sixth year of selection is still pending.

With the breakup of the Community, nationals working with the breeding program returned to their own countries. This has resulted in unexpected disorganization and a manpower shortage in Kenya. There is a serious need for the training of additional people capable of not only organizing the national program but conducting of the programs as well. At the time EAAFRO was disbanded, both the USDA breeder and his EAAFRO counterpart left Kenya.

The protein quality work has only been in operation 14 months. Much further effort is needed if high lysine Opaque-2 quality in an adapted variety is to become an alternative for the maize producer. Selections with acceptable yield and physical grain characteristics must be made from the Opaque-2 converted populations.

The cooperative effort with the USDA plant pathologist in breeding for disease resistance was just getting started when the project breeder left. Sources of maize streak and sugar cane mosaic virus tolerance have been identified and are available but this resistance is yet to be incorporated into varieties adapted to the high and low altitude areas.

Summary and Recommendations

The maize breeding methodology study has made a valuable contribution to Kenya as well as countries throughout the world. No other study of selection method has been as thorough or evaluated under such a wide range of environments. The relative effectiveness of methods of both interpopulation and intrapopulation improvement has been shown.

All germplasm in EAAFRO was made available to each member state during the life of the former East African Community and this germplasm is being utilized in their breeding programs. Genetic materials introduced in the program were used in 90% of the hybrid varieties grown in Kenya in 1976/77. After the breakup of the Community, germplasm from the program was offered to all member countries.

The EAAFRO regional variety trials were distributed to up to 100 cooperators each year from whom a considerable amount of data was returned for analysis and publication of results. This trial was abandoned with the breakup of the Community.

Six young maize breeders received experience and training while in the program. However, this number is very inadequate in light of position changes and manpower needs.

A program to improve protein quality in maize was initiated and, with the completion of the Protein Quality Laboratory, can be effectively continued. Unless the services of the Protein Quality Laboratory are continued, breeding efforts for improved protein quality are impossible. This is a project that must be continued over years before high protein quality genotypes with acceptable kernel quality and yield potential can be expected.

A cooperative program with plant pathological support in breeding for disease resistance was started but, again, is a long-term effort. Virus resistance has been identified but this must be incorporated into adapted genotypes.

The breakup of the East African Community, the return of the USDA maize geneticist to the U.S, and the departure of his African counterpart to head a program in Tanzania unexpectedly, left no experienced leader for the maize breeding effort in Kenya. The effort in breeding for disease resistance and protein quality was just getting underway.

The EAAFRO maize breeding effort was recognized worldwide as unique and effective. Considerable U.S. financial and manpower support contributed to this level of effectiveness. The GOK is now asking for technical assistance because the momentum developed by the program would be lost if the breeding improvement is abandoned in this time of transition. The technical assistance is needed to reorganize the program so that its former effectiveness can be restored.

The USAID Study Team recommends that an experienced maize breeder be stationed at Muguga, which is centrally located and is the proposed lead institution for MOA research. It is recommended that a plant pathologist and entomologist also be located at Muguga to serve partially as backup for this maize breeder in the pest resistance breeding effort. It is also recommended that the MOA assign a senior maize breeder to work with the U.S. technician on a national basis.

It is recommended that the maize breeder and his counterpart:

1. Give guidance and coordination to the national effort in an attempt to restore its former effectiveness and maximize the chance of keeping maize varieties current. They should see that the minimal effort needed to complete the long-term EAAFRO breeding methodology study is completed so that maximum returns of this long-term research investment are achieved and can be utilized by maize breeders worldwide.

2. Work with pathologists and entomologists to ascertain disease problems threatening Kenyan maize, identify sources of resistance, and help introduce this resistance into populations suitable for all maize growing areas. They should assist breeders in the various regions in determining how to select for the resistance needed in their area.

3. Study protein quality in current populations and determine if quality can be improved through selection and at the same time work for high yielding, lodging resistant, acceptable grain type Opaque-2 segregates.

4. Study drought resistance and drought escape possibilities through a breeding approach. This is of major concern in the marginal rainfall areas.

5. Coordinate national variety trials throughout the country in order to identify the potential place for selected materials and to identify potential problems. A major focus of the technicians should be to train and advise maize breeders wherever needed. Emphasis should be on transferring full responsibility for the proposed breeding effort to the MOA as quickly as possible.

The Team recommends that in the interim, until longer term assistance can be provided, the former USDA maize geneticist be made available on TDY to assist in planning and designing the overall Kenyan maize breeding effort. The present national program is understaffed and inexperienced. The TDY is vital to insure continuity of effort and a minimum of loss in momentum. In addition to assisting in the previously mentioned activity, the technician can initiate the assembly and analysis of the results from the long term breeding methods study. The results should be considered for publication as soon as available to insure maximum benefits to breeders in Kenya as well as other parts of the world.

SUB-PROJECT B: CROPPING SYSTEMS FOR MARGINAL RAINFALL AREAS

Background

A. Past Situation

The marginal rainfall (20 to 30 inches/year) areas of Kenya have received much attention from the Government (GOK) in recent years since people are moving into these areas due to population pressure in more productive areas and are cropping land formerly used primarily for grazing. The Government estimate of population growth in the marginal rainfall areas is above the country's average of 3.1 percent per year. This is exacerbated by the migration of families within the marginal rainfall areas from the higher to the lower elevations, where the evaporation rate is high relative to the former and where the arable land cannot meet the food consumption needs under present cropping systems.

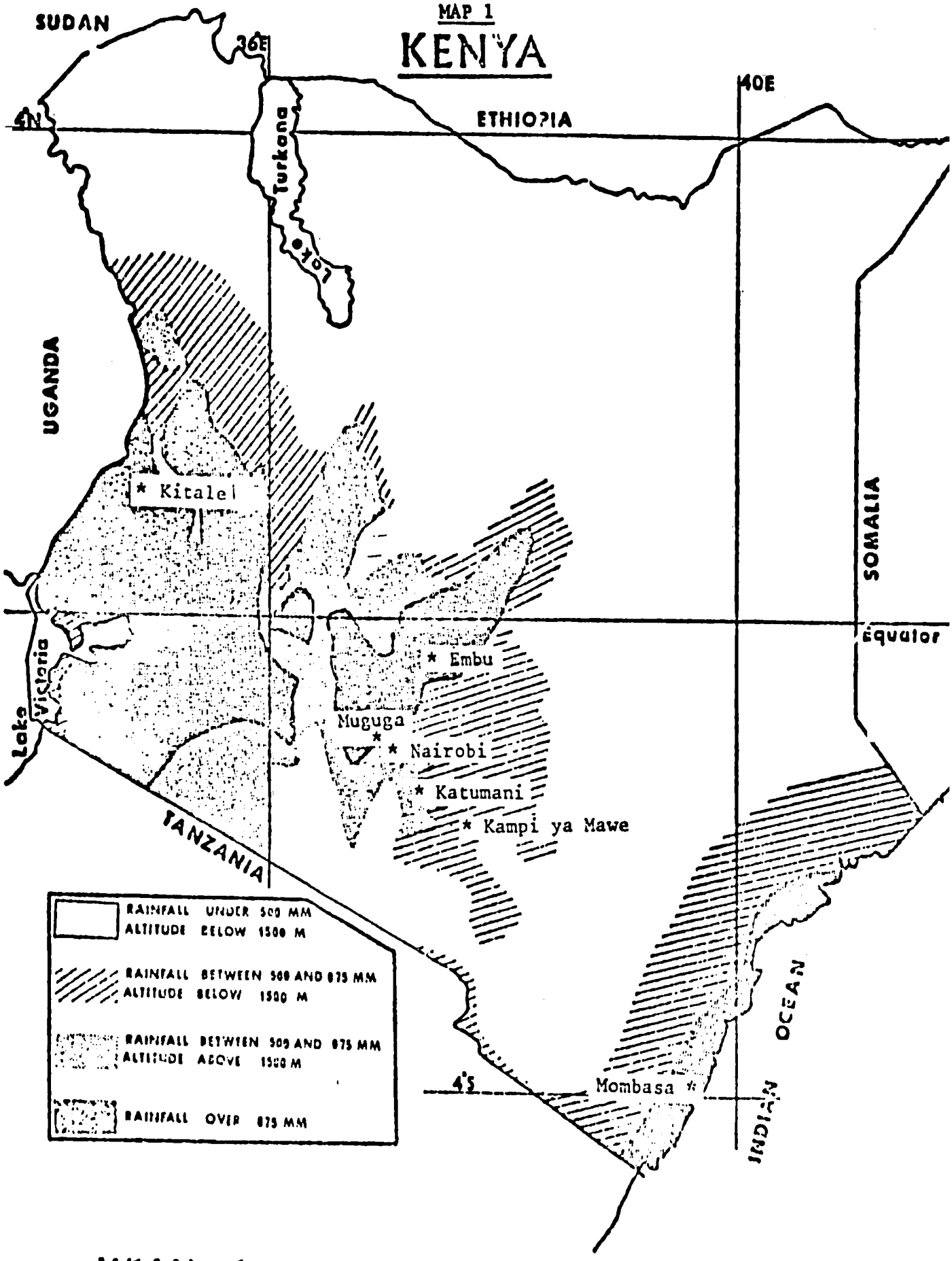
The need for increased food production to meet the demand requirements of the population in general, and those of the marginal rainfall areas (MRA's) in particular, dictates research studies of the cropping systems to determine the feasibility of producing food in areas where crops have periodically failed, and where the normal expectation is due to a combination of factors, including: increased number of farms (extensive use of farming lands); livestock overgrazing, due to increased livestock brought in by the increased population; soil erosion, resulting from overgrazing and heavy sporadic downpours of rainfall when it does rain- and, finally, the lack of adequate rainfall consistent with the needs for favorable crop production.

This sub-project, sponsored by USAID under the "East African Food Crops Project", was to determine cropping systems capable of bringing marginal rainfall or "medium potential areas" (see Map 1) to a level in food crop production that would contribute to the economic wellbeing of the people. The project was designed for the East African Community (EAC) of Kenya, Tanzania and Uganda. However, the Community (EAC) was dissolved on October 1, 1977. Therefore, this evaluation will be restricted to Kenya. However, references to past activities of the other two countries that are of relevance to the project activities in Kenya will be cited.

Rainfall and evaporation data have been recorded for many years in Kenya. However, the changes in cropping practices and population movement into the MRA resulting from the population pressure made these data insufficient for the cropping systems which evolved. The was a need, therefore, to develop new data on evaporation, soils profile, soils depth, water holding capacity, etc., to study the cropping production needs of the area. Furthermore, the considerable amount of knowledge about soil conservation practices in Kenya could not be meaningfully

MAP 1

KENYA



MEAN ANNUAL RAINFALL & ALTITUDE

utilized in areas such as Katumani and Kampi ya Mawe (see Map 1) due to the inadequacies of the soil and water data for those areas.

B. Present Situation

The sub-project, "Cropping Systems for Marginal Rainfall Areas", has two components: One technical (agrometeorologist and agronomist); and the other humanistic (social-economist). The agronomist's research consists of using hydropones and field plot experiments to select crop varieties more suited for the environmental conditions of the area. The agrometeorologist research involves field plot and lysimeter experiments to quantify the water use and yield response relationship of the selected varieties (in collaboration with the agronomist). Based upon this relationship, it will be possible to predict the expected yields for different climatic and soil conditions, assuming rainfall can be predicted with some degree of accuracy. The role of the economist is to establish a socio-economic profile (data base) of the many factors affecting the production as well as distribution capabilities of the area; and to develop farm management models for resource combinations and alternative cropping systems.

The locations where the technical aspects of the project are being carried out are: Katumani (medium potential area above 1,500 meters); Kampi ya Mawe (medium potential area below 1,500 meters); and Muguga (high potential area). The location for the economic and social aspect of the project is within the Districts of Machakos and Kitui, at Katumani and Kampi ya Mawe, respectively. Because of its dietary importance in Kenya, the technical experiments presently are concentrated on two varieties of maize, Katumani 120 and the modified version-Composite 90.

The agrometeorologist's lysimeter experiment is at Muguga; whereas his field plot experiments are at Katumani and Kampi ya Mawe. This aspect of the sub-project began October, 1977, with the first field experiment commencing November 15, 1977, and the second one commencing March 15, 1978. Unfortunately, heavy rains and delays in obtaining materials and equipment resulted in the progress of the lysimeter experiment being less than expected.

The agronomist began his research work on the sub-project in January, 1978, having been transferred from Tanzania where his responsibility in EAC was in sugar cane research. The hydropone and the field plot experiments began in March of 1978. The economic study began in August, 1977, shortly after the agricultural economist arrived.

C. Technical and Institutional Constraints

Rainfall, the moisture holding capacity of the soil, and the predictive ability of the former are the first major set of constraints on the production of food crops in the marginal rainfall areas. These areas are where production of annual field crops is limited by the lack of available moisture but where the use of agronomic practices such as soil conservation methods and adapted crop varieties would make crop production sufficiently reliable to meet the needs of an increased population. Therefore, these constraints are, perhaps, the most serious in the areas of concern.

Since producers cannot change the rainfall of the areas, they must adapt their practices to effectively and efficiently use that rainfall. It is necessary, therefore, to secure an appropriate data base: in the measurement of water regimes, soil holding capacity, soil depth and profile and rate of evaporation; in the determination of crop varieties most suited for the environmental conditions of the areas; and in the determination of the socio-economic requirements of the people in the areas. Indications are that such a data base in the marginal rainfall areas is inadequate at the present time and that established agronomic practices such as terracing, contour tillage, micro-watershed development and others could be more effectively utilized in increasing production. However, this is dependent upon farmers having reliable information on the soil and its water retention capacity, crop varieties and their root system development, crop water requirements and plant responses, and information concerning production and distribution of crops.

Comparatively, farmers in the more developed countries have sufficient information to be able to evaluate these factors with some precision because a well established data base has been developed from experiments and years of experience. In Kenya, there is no such information and this needs to be developed if farmers are to increase production to meet increased demands. This is the overall objective of this sub-project. The availability of soil moisture, rainfall probability, and the predicted response for food crop species will permit rational planning and evaluation of alternative cropping systems. Planting dates also can be chosen using soil moisture readings and an estimate of the time of probable rainfall. The rate of planting of a particular crop that is appropriate under conditions of marginal rainfall can also be determined from the soil/water and crop selection information.

A second set of constraints on food production in the marginal rainfall areas includes the control of insects and diseases, and other pests such as wild animals and birds. Only as existing research by Government and donors and as existing technologies are extended can these constraints be reduced or eleminated.

Other constraints include: factors of production (land, labor, capital and management); Government policies regarding pricing and distribution; and an extension service capable of implementing the research findings, overcoming the reluctance of farmers to adapt new technologies, and finding a means of transforming successful and/or proven agronomic practices and technologies of agriculture in the areas of concern. In regard to these constraints, it is necessary to examine and analyze the socio-economic and other factors affecting and effecting agricultural production and distribution, particularly in the allocation, combination and distribution of resources, the cropping systems and agronomic practices, and the information/dissemination (services) network (capacity) in the marginal rainfall areas.

D. Linkages and Collaboration

Other donors that have collaborated with and/or made contributions to AID's research thrust, directly or indirectly, have been FAO, ICRISAT, IBRD and the EEC. The GOK's Ministry of Agriculture, National Council of Science and Technology, Agriculture Research Council and the University of Nairobi have also lent assistance and/or collaborated in one way or another. Some of the international organizations that carried out activities under the EAC are either no longer functional or no longer maintain collaborative arrangements with Kenya.

Objectives

The primary objective of the sub-project--"Cropping Systems for Marginal Rainfall Areas"--was to develop recommendations for cropping systems that would both increase and stabilize food production levels in the areas of concern in East Africa. However, since the EAC was dissolved in 1977, new objectives, focusing on the marginal rainfall areas of Kenya, have been developed under the two research components: technical (agronomy, agrometeorology); and humanistic (agricultural economics).

The specific objectives, divided into three sub-components, are as follows:

A. Agronomy Research Component

1. To utilize the electrolyte diffusion measurement technique, hydropone and field plot experiments to screen for drought resistant crop varieties.

2. To analyze rainfall data and crop varieties grown in the marginal rainfall areas to identify drought periods during growing seasons and timing of growth stages.

3. To make recommendations for maximizing crop yield response, varieties to be grown and optimum time for planting crop varieties.

B. Agrometeorology Research Component

1. To develop a technical data base concerning water needs for various crops and crop varieties and crop responses to various water regimes.

2. To determine and develop a technical data base on seeding depth, row and plant spacing, time of planting for various crop varieties, the needed soil and water conservation measures, and the water use/yield relationships for various food crops.

3. To screen from available collections and, in collaboration with the Agronomist, select varieties of cereals, legumes and oil crops for tolerance to drought, and physiological adaptation to conditions in the marginal rainfall areas.

4. To develop cropping systems leading to reduced risks of total crop failure due to drought and maximize resources used in the food production of the areas.

5. To develop a system for analyzing the data and for implementing the results at the farm level in collaboration with the economic component and the GOK extension service.

C. Agricultural Economics Research Component

1. To develop the mechanism for a farm household survey to establish a socio-economic data base for the marginal rainfall areas.

2. To develop farm management models for combination of resources that would maximize production under recommended cropping systems for the areas of concern.

3. In conjunction with the other research components of the sub-project, develop recommendations for coordinating the research activities with the extension service activities of the marginal rainfall areas and develop a delivery system for the dissemination of information and the implementation of the research results.

Plan of Work

The work plans developed for each of the three sub-components were designed to satisfy the specific objectives under each sub-component. Each work plan was designed with the following general assumptions:

A. AID and its counterpart (GOK) would provide approved budgeted resources in a timely manner.

B. Weather (rainfall) conditions in the marginal rainfall areas would be normal.

C. Staff workers, including research assistants and trainees, would be made available by the GOK.

The work plans for each research sub-component are summarized below (A-C).

A. Agronomy Research Component

Time Period	Activities
1. January to June 1978	-Construct hydropones, set up and conduct experiments (both lab and field plot); and select maize seeds from different varieties for drought resistant screening.
2. July to December 1978	-Conduct experiments on sorghum varieties in hydropones and field plots. Screen and select varieties for drought resistance.
	-Analyze data from maize experiments and test yield responses to row spacing, tillage and intercropping with legumes.
	-Monitor soil temperature, leaf water potential and leaf diffusive resistance.
	-Test maize to population density, planting date and fertilization.
3. January to June 1979	-Conduct experiments on pigeon peas varieties as above.
	-Test optimum cultural practices for maize for final release and recommendation.

Time Period	Activities
4. July to December 1979	-Continue field study experiment with sorghum and follow procedure as in maize above.
	-Continue experiment with chickpeas and follow procedures as in pigeon peas and sorghum, as above.

B. Agrometeorology Research Component

1. Estimate from October to December 1977	-Construct lysimeter at Muguga, set up and conduct experiments (lab and field plot) at Katumani.
January to December 1978	-Conduct experiments at Katumani, Kampi ya Mawe (field plots) and at Muguga (lysimeter) on maize (two varieties).
	-Begin sorghum experiment October 1978 in collaboration with agronomist for optimum plant spacing, tillage procedures and other required practices.
	-Collect data for establishing data base to fulfill objectives 1-3 (above).
January to September 1979	-Conduct sorghum experiment (continued). -Continue field plot and lysimeter experiments at Katumani, Kampi ya Mawe and Muguga, respectively.
	-Screen from seed variety collections and select varieties of cereals, etc. (Objective 2, page 26) -Objective 4 (page 26)

C. Agricultural Economics Research Component

1. August 15 to November 15, 1977	-Review of literature to determine extent of data collection.
2. November 16 to December 15, 1977	-Develop survey instrument, objective 1, above
3. December 16, 1977 March 15, 1978	-Conduct interview.
4. March 16 to July 15, 1978	-Begin to develop farm management models (objective 2).
5. July 16 to March 15, 1979	-Follow up survey for additional data base.
6. March 16 to July 15, 1979	-Complete farm management models (objective 2 above).

7. July 16, 1979 to July 15, 1979 -Test models and carry out objective 3 above.

8. July 16, 1980 -Develop sectoral management model and make policy recommendations.

Accomplishments

The accomplishments of the sub-project components (technical and humanistic) are presented under each research sub-component (agronomy, agrometeorology and social/economics). These accomplishments are examined under two categories: basic research; and applied research. The economic, social and other impacts resulting from the research are also presented.

A. Agronomist Accomplishments/Outputs

The ~~technician~~ SCIENTIST arrived in January, 1978, having been transferred from Tanzania as a result of the collapse of the EAC. Because his expertise was in sugar cane, it took him sometime to orientate himself to the crops (maize, sorghum, millet and legumes) being researched in the marginal rainfall areas. Moreover, difficulties in obtaining materials and equipment for designing a hydroponic system for drought stress experiments delayed the research work of this technician.

Accomplishments to date include:

1. Review of the literature and study of the rainfall patterns of the marginal rainfall areas of the Machakos and Kitui Districts in an attempt to understand the cropping systems and the physiological suitability of crop varieties.

2. Construction of one hydropone tank, and design of three other tanks in progress.

3. Initiation of a field plot experiment on maize at Katumani (March 13, 1978) consisting of a short season variety maize (Composite 90) with 4 variables--planting in tilled and non-tilled soil, intercropped and monocropped, with three row spacings and two plant populations within spacing.

4. Planted a field trial plot of 40 sorghum varieties introduced from Nebraska for observation.

The accomplishments/outputs of the agronomy research component has been negligible due, in part, to the limited time (3 months) the research has been underway, and, in part, due to the difficulties in obtaining materials and equipment. However, the team viewed this research component as one which, unless the quality of the plot research is improved will have little value in defining the problem for which

it is intended. The economic and social impacts of this research component are likely to be negligible.

B. Agrometeorologist Accomplishments/Outputs

Uncertainties and indecisions by AID/USDA concerning the EAC (prior to its collapse in July, 1977), the appointment of technicians, and the activities of the sub-project caused considerable delays in ordering equipment and instrumentation for the agrometeorology component. The lysimeter and field plot experiments were, therefore, delayed for several months.

Accomplishment to date include:

1. Installation of the lysimeter experiment at Muguga to quantify the water use and yield response patterns of selected crop (maize) varieties.

2. Installation of the water storage tank and irrigation system at Katumani to create a gradient of water output from the irrigation sprinkler to the edge of the field for studying growth of maize and sorghum varieties and other crops under different water regimes.

3. Installation of evaporation pans underway at weather stations at Muguga, Katumani and Kampi ya Mawe for weather information.

4. Installation of instruments (housed in a mobile unit) in collaboration with the agronomist at Katumani to measure leaf-water potential.

5. Completion of a field plot experiment on maize (November, 1977 - March, 1978) to determine water and yield relationships of two varieties (Katumani 120 and Composite 90) in three population levels (planted normal, 2/3 of normal, and 1½ times normal) under seven water regimes.

6. Initiation of two field experiments on maize (begun March 13, 1978) at Katumani and at Kampi ya Mawe (a repeat of 5).

7. On-the-job training of technicians has been started.

The economic, social and other impacts of this sub-project component on the economy (farmers and/or consumers) cannot be realized immediately. The objective of the (stage one) research is to establish a data base from which analyses and predictions fulfilling objectives 4 and 5 can be forthcoming. Assuming that a good data base can be established and that appropriate predictive methodologies can be developed for analysing the data, the expected results could be useful to farmers only if an information/dissemination capacity at the extension level (stage two) is established so that the results can be implemented.

C. Agricultural Economist Accomplishment/Outputs

The Agricultural Economist has been on the sub-project longer than the other two technicians (since August, 1977); and appears to have had less difficulties in obtaining resources for his research. His outputs/accomplishments, when viewed with the others, hardly reflect the advantage of having more time and less difficulties in meeting his objectives.

Accomplishments to date include:

1. Review of the literature, which revealed that the data recently collected by the Division of Research of the Ministry of Agriculture (MOA), were adequate to satisfy activities 2, 3 and 5 of the work plan.

2. Tabulation of the data from the Integrated Rural Survey of MOA and construction of the management model (activity No. 4 work plan) are in progress.

3. Reconnaissance survey of the Machakos and Kitui Districts.

Additional Work Required

With the collapse of the EAC and a refocus of the Food Crops Research Project from the EAC to Kenya, the activities of the sub-project "Cropping Systems for Marginal Rainfall Areas" were delayed to allow for a transition that included: replacement and relocation of technicians; reallocation and ordering of resources; and development of guidelines within the context of GOK priorities. Consequently, many of the objectives of the sub-project components have not been accomplished and require additional time. Therefore, additional work as presented below is within the context of the present objectives and consistent with the sub-component work plans. Additional work required outside the present scope of work will be presented in the last section (VI), below.

A. Agronomy - Work Required

The experiments to date have been limited due to inclement weather, lack of adequate resource support for material and equipment and, perhaps, a clear direction as to what needs to be accomplished and what methodology should be used. In accordance with the work plan for this component of the sub-project most of the activities remain to be completed. They include:

1. Implementation of the hydroponic system for drought stress by electrolite leakage method.

2. Field trial plot experiments at each of the research sites (at Katumani and Kampi ya Mawe) for each of the crops and varieties (maize, sorghum and legumes).

3. Analysis of the data and information obtained from the experiments.

4. Interpretation of the results and recommendations for implementation.

Agrometeorology - Work Required

This component of the sub-project is perhaps the most advanced in terms of accomplishments, yet there is a considerable amount of work to be accomplished if the objectives are to be met consistent with the work plan. These activities include:

1. Experiments using the lysimeter apparatus at Muguga and the field plots at Katumani and Kampi ya Mawe on maize, sorghum, etc.

2. Collection and tabulation of relevant water regimes, crop varieties and other data.

3. Development of systems for analyzing the data and for implementing the results at the farm level in collaboration with the agronomist, the economist and the GOK.

C. Economist - Work Required

This component of the sub-project requires, in addition to the analysis of data by the use of management models, a thorough study of the socio-economic environment of the marginal rainfall areas. It requires the establishment of a firm, and as complete as possible, data base of the management, production and marketing systems of the areas, including input/output data and the pricing systems.

Further work required to meet the objectives, consistent with the work plan, include:

1. Collect socio-economic and other data that are not yet available.

2. Develop workable management models for analyzing the relevant data.

3. Develop, in conjunction with the agronomist, the agrometeorologist and the GOK, a delivery system for the dissemination of information and the implementation of the research results.

Summary and Recommendations

The sub-project - "Cropping Systems for Marginal Rainfall Areas" - was designed in the context of the EAC's Agricultural Program and its priority of increasing food production in the marginal rainfall areas (20 to 30 inches/year). In this region, population pressure has exerted an increasing demand on the food production capacity. Since the collapse of the EAC in 1977, the focus of the project has shifted to Kenya.

The purpose of this sub-project, as evaluated in the Kenya context, was to determine cropping systems capable of bringing marginal rainfall areas ("medium potential areas") up to a level in food production that would meet the needs of at least those people in the areas.

The two components (Technical and Humanistic) of the sub-project has three sub-components and technicians in agronomy, agrometeorology and agricultural economics. Each sub-component has the common objective of developing recommendations for cropping systems that increase and stabilize food production levels in the marginal rainfall areas. Constraints affecting each sub-component include: limited rainfall; low soil moisture holding capacity; insects, disease and animal pests; limited resources inputs; and inadequate policies on pricing and distribution.

Accomplishments that were to have been achieved through basic laboratory and applied field experiments, analyses and implementation, using established methods, have been only minimal; thus the majority of the objectives have not been achieved. In order to accomplish the major objective of increasing food production in the marginal rainfall areas, the research thrust needs to be re-focused - consistent with the priorities of the GOK, the realities of the marginal rainfall areas and the needs of the target group(s) (beneficiaries).

Agriculture is the dominant sector of Kenya's economy in terms of employment and contribution to GNP. GOK, therefore, strongly emphasizes agricultural development for increasing production with relatively low capital (hence the small limited resource farmers), gap (equitable income distribution). In terms of long term development, the marginal rainfall areas are critical, but equally important is the immediate need for their productive capabilities, brought about by demand generally and population pressure in particular, to be realized if the beneficiaries are to receive any benefits.

The team, therefore, recommends:

1. That the objectives of each research component of the sub-project be reformulated on a more realistic and practical basis so that the results can have meaningful applicability to the target group(s). Specifically:

a. that the electrolyte diffusion measurement technique of the agronomist be modified so that the experiments can be conducted under conditions that approach normality for the areas;

b. that more careful selection of experiment plots be made in future experiments to minimize the extreme variability of plant size and other conditions within trial plots as observed by the evaluation team;

c. that soil fertility be inventoried via soil tests and fertility variables be included in field trials.

2. That the activities of the sub-project components be integrated so maximum cooperation and collaboration with technicians of the existing sub-projects can be realized to foster a systems approach in fulfilling not only the objective of increasing food production but also to enhance overall development of the areas of concern. Specifically:

a. the agricultural economist needs to conduct his research activities so that a comprehensive social and economic profile of the areas can be documented and the relevant information be disseminated to research technicians, extension workers and the target group(s) as appropriate;

b. although information obtained from the GOK can be most useful, the agricultural economist needs to become familiar with the farming techniques, practices and requirements of the areas through personal observation which, though not quantifiable for his management models, can be extremely useful in setting parameters and assumptions.

3. That the additional work required under each component of the sub-project be revised to reflect the thrust of the changes suggested above; and that the development of new work plans be done in collaboration with the Director at Muguga (Dr. F. Wang'ati).

4. That the agronomist be allowed to complete his tour of duty under a revised work plan, consistent with the suggested changes.

5. That the agrometeorologist be allowed to complete his tour of duty under a revised work plan, consistent with the suggested changes; and that his research work be re-evaluated prior to the end of his tour to determine whether or not the project is to be continued.

6. That the agricultural economist be allowed to complete his tour of duty under a revised work plan, consistent with the suggested changes.

SUBPROJECT D:

PLANT QUARANTINE

Background

The Plant Quarantine Station was established to serve East Africa in 1931. From 1931 to 1951, vegetatively propagated plant material of specified species was quarantined at the East African Agricultural Research Station at Amani, Tanzania. In 1951, this station was closed and the staff moved to the present location at Muguga, Kenya, as the nucleus of the newly formed East African Agriculture and Forestry Research Organization. At first there was no quarantine facility, but the need was quickly realized. Under the leadership of H. H. Storey, buildings and several small greenhouses were built. The station opened in 1954 and, from then until 1970, Dr. F. M. L. Sheffield, a British plant pathologist, was in charge. Since 1970, the station has been under the direction of a plant pathologist of the USDA with funds provided by USAID.

The Plant Quarantine Station (PQS) at Muguga is probably the largest and best in Africa. It has excellent physical facilities, including eighty glasshouses, laboratories and adequate office space. There are presently 35 staff members, two of whom are research officers. Except for Dr. W. J. Kaiser, a USDA plant pathologist who has served as Head of the unit since 1974, the staff is composed entirely of East Africans.

PQS is basically a service unit. It plays a vital role in importing plant material of many crops for breeding programs and other research efforts.

In addition to the service function, the PQS conducts applied research in plant quarantine pathology, tissue culture, and horticulture. The purpose of this research is to provide improved and expanded services to parties interested in importing plant material.

A concern at this time is that the breakup of the East African Community has weakened the plant quarantine procedures in these countries. Any pest or disease-causing organism introduced into any one of these countries is likely to spread throughout the area. Thus, it is not enough for Kenya alone to have an effective plant quarantine. Regrettably, the other countries in East Africa lack the ability to start their own quarantine station now. Fortunately, they recognize the need for this service and informal steps have already been taken by Tanzania to have the station at Muguga serve their needs on a fee basis. Formal arrangements have not been made yet, but the Inter-african Phytosanitary Council, in which all OAU members are involved, may play a role. In any case, competent leadership, in which Tanzania and Uganda have confidence, will be essential to initiate this program.

Objectives

The original objectives of the subproject were:

1. To import and provide to recipients disease and pest-free plant materials that require quarantine into East Africa.

2. To provide enough material to recipients so they can effectively increase the material for its intended use.

3. To provide plant quarantine information to people who may wish to import materials.

Gradually these objectives were expanded to include applied research in the following areas:

1. The development of new methods to detect the presence of viruses in crops where methods are presently inadequate.

2. The development of tissue culture and heat treatment procedures to free infected plant material of viruses.

3. The development of improved methods to rapidly multiply vegetatively propagated plant species that are released from quarantine.

Plan of Work

The PQS plans to continue to obtain and process as quickly as possible plant materials requested and considered to be of high priority. In conjunction with this, the station plans to locate additional reliable sources of plant materials from different countries. This will include the importation of peach, apricot, plum, apple and pear trees that are virus-indexed and require short chilling periods.

Part of the plan of work called for expansion of the PQS. Included in this was reconstruction of the phytotron that was destroyed by fire. Expansion also involved relocating the repository of released vegetatively propagated material to a 10 acre site behind the quarantine station. In addition, plans included the conversion of a small room to an isolation chamber for seed pathology work and to use the previous facility exclusively for tissue culture work.

Research plans call for trying to find test plants that can be used to index viruses for which there are no adequate methods at this time. Additionally, efforts are to be made to develop serological techniques to detect viruses in potato.

Studies are also planned to determine the cause of ratoon stunting of sugarcane in Kenya and to determine if the hot water treatment presently used is adequate to free the cane of this pathogen. Research work also calls for combining heat treatments with tissue culture techniques to free virus-infected plant material.

Attempts to improve various methods of vegetatively propagating plant species such as cocoa, banana, pineapple, peach, apple, pear, grape, avocado and yam were part of the work plan. Additionally, attempts will be made to improve the budding and grafting of both temperate and tropical fruit trees. Finally, research efforts are to be directed toward controlling the red spider mite by biological means in the greenhouses.

Accomplishments

A. Technical

From 1974 through March of 1978, the station received 4,596 introductions representing an average of 38 genera per year. Legumes represented more than 50 percent of these accessions. Of this amount, 2,492 were tested and approved for release. A total of 50,971 seeds from different plant species were tested for freedom from plant pathogens. Accessions totalling 3,245 were indexed for the presence of plant viruses during this period. More than 200 lines that have been released from quarantine are being maintained in in-door repositories and approximately 750 in outdoor repositories. This includes over 500 varieties of sugarcane, as well as grapes, fruit trees, banana, cassava and miscellaneous tree species. Material from the virus-free mother trees will be made available to researchers in Kenya and elsewhere.

In research work, studies were completed on alfalfa mosaic virus, a potentially important virus that was found infecting lucerne and potato. This is the first record of this virus in East Africa. A seed-borne virus of mungbean that was intercepted in plant quarantine has been found to be a strain of bean common mosaic virus. Studies were completed on its host range, transmission by aphids, and serological properties.

Research on the use of tissue culture techniques, with and without the use of heat treatment, to free vegetatively propagated plant materials of viruses, has been successful in several cases. An unidentified virus of sweet potato was eliminated in two lines, sugarcane mosaic virus was eliminated from five lines of sugarcane, dahlia mosaic virus from four lines of dahlia, two viruses from seven lines of cassava, five viruses from eighteen lines of potato, and one unidentified virus from asparagus.

Research in rooting, budding and/or grafting has aided in the propagation and multiplication of the following plant species: apple, pear, appricot, avocado, peach, plum, fig, quince, banana, cassava, sweet potato, mango, pineapple and raspberry.

To insure that the work of the PQS is understood, and to encourage researchers not to import plant materials illegally, the Head of the Quarantine station has made an average of ten trips annually to research stations throughout East Africa. A major effort has been made to inform the general public, embassies, foreign aid missions, etc., that East Africa has rules governing the importation of plants and that indiscriminate importation of plant materials could lead to the introduction of new and dangerous pests and pathogens. The number of visitors to the station averages 250-300 annually, which helps to make the activities of the station known throughout East Africa and elsewhere.

One of the major accomplishments of the PQS has been to obtain overseas training for the staff. Since 1974, two laboratory technicians have been sent to the United States for training in plant quarantine; two laboratory technicians have gone to Denmark for training in seed pathology; two have learned tissue culture and virus indexing techniques in Peru, and another studied tissue culture techniques in Canada. In addition, a research officer has been trained in crop protection in the Netherlands and a laboratory technician has been trained in this work in the United Kingdom.

Finally, it should be mentioned that in the past five years, 40 new glasshouse units have been completed and put into operation. Also, one propagating house, three single unit research glasshouses, one coldroom, one fumigation chamber, three growth chambers and one isolation chamber have been constructed. As previously mentioned, a ten acre planting site adjacent to the station has also been readied for use.

B. Significance for Kenya

The significance of the PQS to agriculture in Kenya as well as throughout East Afrcia is difficult to quantify because of the nature of work. However, it has enabled plant breeders and other plant scientists as well as farmers and commercial agricultural firms to introduce new plant material into Kenya. Some of these are new varieties or species of immediate benefit, but the value of most will be realized when plant breeders incorporate desirable genes from these introductions into new varieties of crop plants being developed to insure stable food production in East Africa. Without the quarantine station, the Kenya Government would probably be forced to ban most imports. This would hamper efforts to improve crops and would likely result in illegal introductions, many of which might jeopardize some of the subsistence and cash crops grown in the area. The consequences of this could be disastrous, especially in view of the population pressure in East Africa. The validity of this statement is evident when one considers that cassava production is impossible in parts of Uganda

because of the cassava mite that was introudced on cassava plants brought into East Africa illegally. Similarly, sugarcane smut is a serious disease which is thought to have been brought into East Africa on illegally imported cane.

Additional Work Required

The main taks remaining is to insure that the high standards that have been established in the past few years continue. Without competent leadership, the tremendous progress that has and is being made will almost certainly collapse.

Summary and Recommendations

The Plant Quarantine Station at Muguga is one of the largest and best in Africa. It has excellent physical facilities and a well trained operational staff but no one capable of assuming overall responsibility for leadership. With the exception of Dr. Kaiser, Head of the unit, all are East Africans.

The philosophy of the station is not to keep out plant material but to facilitate importation of material to improve crop production in Kenya and other East African countries. To accomplish this, applied research is conducted to develop new techniques to detect viruses, to develop tissue culture and heat treatment procedures to free virus-infected material, and to develop new techniques to rapidly multiply material released from quarantine for use by researchers. As part of the effort to aid development of new or improved crops in Kenya, the station maintains a large repository of healthy plants that is available for use by researchers.

As part of the service function, more than 900 accessions are processed through quarantine each year. An average of 10,000 seeds are tested yearly for freedom from seed-borne plant pathogens and over 600 accessions are indexed annually for viruses.

Training has been an important function of the station. In the past five years, one research officer and seven laboratory technicians have received overseas training in specialized areas such as plant protection, plant quarantine, tissue culture and virus indexing techniquws.

The future success of the station and of all quarantine in East Africa is threatened for two reasons:

1. A strong Head is required to administer the operation and provide technical guidance. The Kenyan who went to the United States and received a Ph.D. degree in virology with the expectation

that he would return to assume this position may now elect to accept a position at the University of Nairobi.

2. The collapse of the East African Community has left Tanzania and Uganda without any quarantine facility and without the technical competency to develop their own program at this time. If they import plant material without going through quarantine, pests and pathogens will certainly be introduced and spread throughout East Africa.

The Kenyans have made tremendous progress in developing an excellent quarantine facility and they now have a fine cadre of trained laboratory assistants and other personnel to carry out the work of the station. They clearly recognize that the continued existence of a first-class quarantine facility is of paramount importance to the future of agriculture in their country. Regrettably, the training of a Kenyan to assume the position of Head of the Quarantine Station is the one area where they have not been successful. But, this is not because they haven't tried. It must recognized that there are very few trained plant pathologists in Kenya, and the person who was sent to the United States for a Ph.D. with the expectation that he would return to assume the duties of the Head of the Station, is the only trained virologist in the country. For this reason, his talent is very marketable and he may join the faculty at the University. In view of the shortage of trained plant pathologists in the country, especially in virology, it must be recognized that should he leave the station, he will still be able to make a great contribution to plant health in Kenya.

For sixteen years the British provided leadership to operate the Plant Quarantine Station and for the last eight years USAID has provided leadership and support to develop the physical facilities and talent necessary to carry out the duties of the station. Today, the station is among the best of its kind in the world. All of this investment could be lost if leadership is not provided by USAID until Kenya can identify and/or train the right person for the position of Station Head. In the meantime, it is suggested that USAID provide the person for this position under the USDA/PASA, but as soon as a Kenyan can be brought in, even if only as an Acting Head, the USDA appointee should become an advisor. He could help the Kenyan technician develop administrative skills, learn the technical aspects of the job with which he or she would be unfamiliar and gain the respect required to function effectively. Under a reorganization plan developed for the Muguga station, the position will be advertised and it is hoped that someone professionally qualified for the position can be selected.

Undoubtedly, the present Head, Dr. Kaiser, is best qualified to assume the role of an advisor. He is accepted throughout East Africa for his technical competency but perhaps more importantly, for his ability to understand local needs and problems. He is dedicated to training Kenyans to assume the complete responsibility for the station. If Dr. Kaiser could be freed from the daily chores of running the station, he not only could help the Acting Head to eventually assume complete responsibility for the station, but he could also play a vital role in convincing Tanzania and Uganda that the competency of the station is being maintained and their use of its services on a fee basis would insure the safety of agriculture throughout all of East Africa. Should Dr. Kaiser not be available for this assignment, an effort should be made to obtain the services of an experienced plant quarantine officer, such as Dr. R. P. Kahn, wo was Head of the station from 1970-72.